# Preharvest and Harvest Food Safety

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## Food Safety Hazards

- A
  - biological,
  - chemical, or
  - physical property

  that is *reasonably likely* to cause
  - cause injury or illness

  in the absence of its control

## Chemical Hazards

- If not controlled will cause illness
  - Chemicals
    - Pesticides
    - Sanitizers
  - Allergens
    - Undeclared ingredients
    - Cross contaminants
  - Unapproved additives
  - Natural toxins
    - Mycotoxins
      - E.g., patulin

## Physical Hazards

- Foreign objects capable of injuring the consumer
  - Metal
  - Glass
  - Wood
  - Hard plastic
  - Stones

## Biological Hazards

- If not controlled will cause illness
  - Bacteria, e.g., *Salmonella*
    - Or their toxins (e.g., *Clostridium botulinum* toxin)
  - Viruses, e.g., hepatitis A
  - Parasites, e.g., protozoa
    - *Cryptosporidium parvum*

## Produce Increasingly Recognized as Vector

- Proportion of reported outbreaks
- USA
  - 1970s: <1% (outbreaks) <1% (cases)
  - 1990s: 6% (outbreaks) 12% (cases)
- Australia
  - 4%: (2001-2005)
- Europe
  - Increases in past decade

Lynch et al., Epidemiol. Infect. 2009

## Multinational Outbreaks

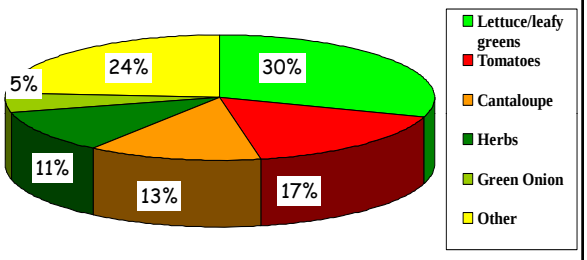
| Year | Pathogen | Cases | Regions | Food |
|---|---|---|---|---|
| 2008 | *Salmonella* | 1442 | North America | Fresh peppers, tomatoes? |
| 2007 | *Salmonella* | 51 | Europe, North America | Fresh basil |
| 2007 | *Shigella* | 175 | Australia, Europe | Alfalfa sprouts |
| 2007 | *Salmonella* | 45 | Europe | Alfalfa sprouts |
| 2006 | *E. coli* O157:H7 | 206 | North America | Fresh spinach |
| 2006 | *Salmonella* | 20+ | Europe | Arugula |

Lynch et al., Epidemiol. Infect. 2009

## Why the increase?

- Increased consumption
  - More raw, less cooked
- Large scale production, widespread distribution
  - Increasing size of outbreak increases ability to detect
- Increase in sensitive populations
- Increase in public and scientific awareness
- Greatly improved methodology

## 1998 – 2006 Produce Outbreaks




Top 5 produce items make up 76% of outbreaks

## Recurring Pathogen and Commodity Combinations

- *Salmonella* Poona and *Salmonella* Anatum
  - cantaloupes
- *E. coli* O157:H7 (other EHECs?)
  - lettuce and leafy greens
- *Salmonella*
  - mangoes, tomatoes, almonds (nuts)
- Hepatitis A
  - green onions
- *Shigella sonnei*
  - parsley, cilantro, and culantro

## Do Fresh Cut Products Have Higher Risks ?

## 1998-2006 Fresh Cut Produce Outbreaks

- Romaine lettuce 2
- Lettuce 6
- Mixed lettuce 1
- Spinach 2
- Roma Tomatoes 2
- Round Tomatoes 1
- Mixed melons 1

## Recent Outbreaks Have Caused Major Changes in Attitudes and Approaches to the Safety of All Perishable Produce

In the U.S., since 1999, 80% of leafy green outbreaks and 98% of illnesses have been from fresh-cut products

## Survival/Growth of Pathogens in Produce

- Intact fruit/vegetable
  - Survival variable, growth rare
- Cut/wounded fruit/vegetable
  - Survival increases and growth possible
- Temperature
  - Growth slowed at lower temperatures
  - SURVIVAL often increases at lower temperatures
- Humidity
  - Growth and survival enhanced with higher humidity

## Growth of Pathogens in (cut) Produce

- High pH/low acid products:
  - Growth can be rapid at room temperature
  - examples: sprouts, cut melons, chopped parsley, chopped lettuce, shredded carrots
- Low pH/high acid products
  - Tomatoes: Under some conditions, chopped tomatoes will support the growth of *Salmonella*
  - Apples: Wound will support the growth of *E. coli* O157:H7

## Innovative Packaging

- Longer shelf life due to suppression of spoilage organisms and physiological degradation
  - Modified atmosphere packaging
  - Vacuum packaging
  - Shrink-wrap packaging
  - Customized films
  - Controlled atmosphere storage

## Toxin Production by *Clostridium botulinum*

| Product | Temp. | Days to Toxin | Product Quality |
|---|---|---|---|
| Romaine | 21 | 14 to 21 | Inedible |
| Shredded cabbage | 21 | 7 | Inedible |
| | 22 to 25 | 4 to 6 | Acceptable |
| Sliced potatoes | 22 | 3 | Marginal |
| Sulfited potatoes | 22 | 4 | Acceptable |

## Contamination/Handling Errors

- Have occurred at:
  - Production
  - Packing
  - Processing
  - Final preparation
- Contamination MOST important factor
- Temperature abuse SOMETIMES contributes
  - Most critical in low-acid fruits and vegetables
    - Pathogens can multiply when fruit or vegetable cut
  - Only critical with bacteria

## Washing Doesn't Eliminate Pathogens

- At best 1-3 log (1 to 1000-fold) reductions can be expected under commercial conditions regardless of antimicrobial used
- Issues
  - Complexity
  - Stem scar area
  - Apples
    - Bacteria can enter core through blossom end
    - Stem end difficult access
  - Presume knife can transfer to edible flesh
    - Demonstrated for melons and tomatoes

## Infiltration Can Occur in Some Products


**Fruit pulp must be < 9ºF warmer than water temperature to prevent infiltration.**


**Apples**
**Melons**
**Peppers**
**Spinach**
**Mango**

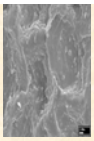
**Temp**
**Pressure**
**Depth**
**Water deficit**
**Vacuum**

Maintaining water sanitation critical

T.V. Suslow, UC Davis

## Not all surfaces equal

Honeydew Melon Surface



- Smooth surfaces
  - Honeydew melon, tomato, oranges, apples

Cantaloupe Surface

- Complex surfaces - hard
  - Netted rind difficult to "clean"
  - Scrubbing with clean brush significant improvement
- Complex surfaces - soft
  - Strawberries, broccoli, lettuce, parsley, sprouts

## Some surfaces may attract bacteria

- Lettuce
  - *E. coli* O157:H7 found in cut edges and stomata (Seo and Frank, 1999)
  - *L. monocytogenes* and *Salmonella* attach to cut edges (Takeuchi et al., 2000)

## Guiding Principles of Food Safety for Fresh Produce

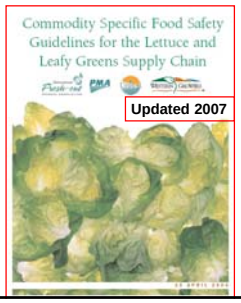
- Once contaminated, removing or killing pathogens is VERY difficult
- THEREFORE
- Prevention of contamination is favored

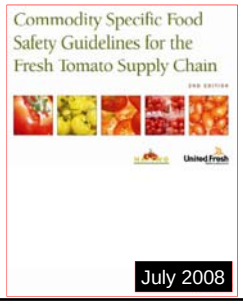
## GAPs and GHPs ARE Science-based

- Guidance derived from sound principles
- Data is lacking in many areas
- Specific practices and standards may
- have no *validated* basis

## Good Agricultural Practices Now Incorporate More Specific "Metrics": Criteria for Compliance Audits

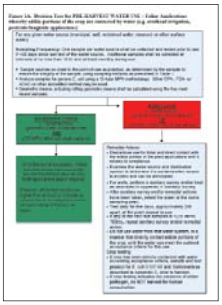
- **Quantifiable and verifiable criteria**
- **Improve public safety by applying uniform science-based standards**

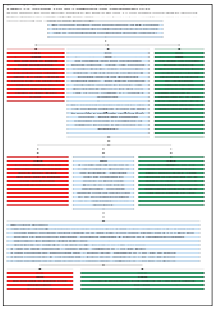



## Leafy Green Marketing Agreement

- ***Accepted More Specific and Prescriptive "Metrics"***
- ***Voluntary Program; Mandatory Government Audits***





## FDA Produce Safety Rule

- The Food and Drug Administration is proposing to promulgate regulations setting enforceable standards for fresh produce safety at the farm and packing house.
- http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=200910&RIN=0910-AG35
- Intention to publish a proposed rule in 2011

**What are the sources of contamination?**

## Enteric (Fecal) Pathogens (partial list)

| Pathogen Multiply in Foods? | Enteric Source | Infectious Dose | Sequelae |
|---|---|---|---|
| BACTERIA | | | |
| *Salmonella* spp. **YES** | human animals | 10 - 100,000 | Reactive arthritis |
| *E. coli* O157:H7 (EHEC) **YES** | human animals | 10 - 1,000 | HUS |
| *Shigella* **YES** | Human | 10 - 100 | Dysentery |
| PROTOZOA | | | |
| *Cryptosporidium* **NO** | human animals | <20 | Severe diarrhea |
| VIRUS | | | |
| Hepatitis A **NO** | human | 10 - 100 | Jaundice |

## Routes of Contamination



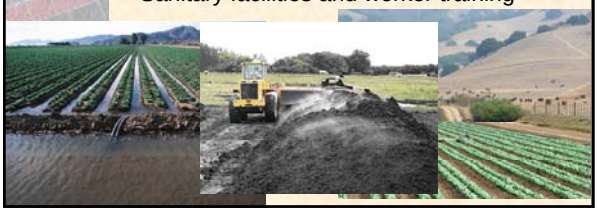

Beuchat, 1996

## GAPs Metrics

- Mandatory Good Agricultural Practices (GAPs) developed by a panel of industry members, academics and scientists
  - Represent the best practices available
  - Flexible enough to evolve over time as science advances
  - Target water and inputs, wildlife and worker hygiene

## Metrics

- Adjacent land use
- Distance from animal operations
- Water and water testing
- Application/testing of compost
- Sanitary facilities and worker training

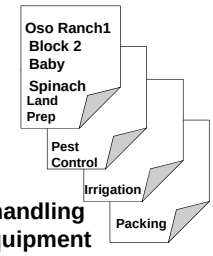


## Implementing GAPs

**Step 1: Construct a Self-Audit of Potential Hazards**

- **Site selection**
- **Animal influences**
- **Fertility inputs**
- **Water inputs**
- **Irrigation**
- **Foliar sprays**
- **Harvest**
- **Human influences**
- **Worker hygiene**
- **Postharvest water and handling**
- **Sanitation – field and equipment**

**Record Keeping is Essential !**




## Best Practices: Irrigation Water

**Water Source**

**Known Impaired** — **Purified**

How do you define water quality?

- **Indicator threshold**
- **Pathogen testing**
- **Treatment**

## Best Practices: Irrigation Water

**Water Source**

**Known Impaired** — **Purified**

What factors should influence acceptability?

- **Method of irrigation**
- **Type of crop**
- **Contact with edible portion**
- **Crop habit and surface morphology**
- **Cropping cycle**
- **Climate and microclimate**
- **Timing of last irrigation to harvest**

## Best Practices: Site Selection

How far from an identified hazard?

## Best Practices: Site Selection

What factors should influence acceptability?

- Slope
- Soil porosity
- Prevailing wind
- Presence of vectors
- Method of irrigation
- Crop habit + morphology
- Season
- Mitigation practices

## *E. coli* O157:H7 Outbreak Associated with Bagged Lettuce (Taco Johns) (December 2006)

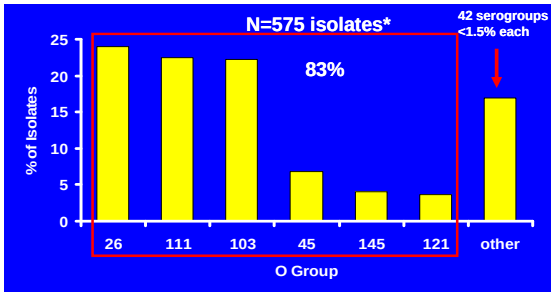
- **81 cases of *E. coli* O157 infection in three states**
  - **2 cases of HUS, 26 hospitalizations**
- **Implicated vehicle – Bagged, fresh-cut lettuce**
  - **Grown in California's Central Valley**
  - **Outbreak *E. coli* O157:H7 strain isolated from 2 environmental samples from 2 dairy farms near lettuce-growing area**
- **Irrigation water cross-linked to dairy waste water used to irrigate animal food crops**
- the farm irrigation system that utilized dairy runoff water did not have any backflow prevention devices to ensure manure-blended irrigation water did not contaminate the SWSD water system," which was used to irrigate lettuce fields

U.S. Food and Drug Administration
www.fda.gov/bbs/topics/NEWS/2007/NEW01546.html

## *E. coli* O157:H7 Outbreak 2006 Bagged Fresh Spinach

- 45 of 351 (13%) of environmental samples in and around the Ranch were *E. coli* O157:H7-positive
  - Outbreak strain of *E. coli* O157 confirmed from 26 of 45 *E. coli* O157:H7-positive samples
  - These were from **cattle feces** (15 samples), wild pig (7 samples), stream water (2 samples) and soil (2 samples)

## Human isolates of non-O157 STEC, by serogroup, FoodNet sites, 2000-2006




Source: CDC 2008

## Best Practices: Animal Intrusion

**Observed fecal matter**

| Ignore it as natural | Segregate 5 ft area | Reject whole field |
|---|---|---|

| Significant Animal |
|---|
| • Cattle |
| • Pig |
| • Deer |
| • Goat |
| • Sheep |

| Non-Significant Animal |
|---|
| • Coyote |
| • Fox |
| • Dog |
| • Cat |
| • Horse |
| • Rabbit |
| • Raccoon |
| • Birds |
| • Chickens |
| • Reptiles |
| • Amphibians |
| • other |

**LGMA Standards recognize level of concern and required corrective action**

## Human hygiene

**Humans are involved**

- training and implementation issues

**Multiple touch points**

## GAPs Programs Should Not Be Passive

Develop a system that can:

- Determine what could have happened;
- Implement procedures to determine when the process is out of control;
- Implement control measures to correct the problem;
- Verify;
- Record all actions that have been done

44

## Key Take-Home Messages

- Illness is the vastly exceptional outcome
- Diverse produce consumption is the right health message for a balanced diet